

Claims

1 Machine vision equipment incorporating automatic set-up means; said equipment comprising:

imaging means comprising a camera defining a field of view and being adapted to form an image of a test object within said field of view, and processing means for processing said image for determining one or more physical properties of said test object;

first supporting means for supporting a test object within said field of view at a predetermined distance from said camera;

characterised by:

10 second supporting means for supporting a reference object having at least one accurately known dimension;

moving means for selectively moving one or more of the camera, the first supporting means, and the second supporting means such that a reference object placed on the second supporting means is disposed within the camera's field of view at said predetermined distance from said camera;

15 adjusting means for automatically adjusting the configuration of the imaging means;

optimum configuration determining means for determining the optimum configuration of said imaging means by processing one or more images of a reference object placed on the second supporting means; and

20 controlling means for controlling operation of said moving means, imaging means, adjusting means, and optimum configuration determining means for bringing a reference object supported by said second supporting means into the camera's field of view, imaging said reference object, determining the optimum configuration of the imaging means, and 25 adjusting the imaging means to said optimum configuration.

2 Machine vision equipment as claimed in claim 1, characterised in that said optimum configuration determining means are adapted for determining the optimum configuration of the imaging means by processing a plurality of images of said reference object obtained with said imaging means in different respective configurations, and said 30 controlling means are adapted to control said imaging means, adjusting means, and optimum configuration determining means to obtain and process serial images of said reference object means whilst adjusting progressively the configuration of the imaging means, and to determine the optimum configuration on the basis of said serial images.

3 Machine vision equipment as claimed in claim 2, characterised in that said adjusting means are adapted for adjusting the focal length of the camera, said optimum configuration determining means comprise optimum focal length determining means, and said controlling means are adapted for controlling the adjusting means, imaging means, and optimum focal length determining means to obtain and process serial images of the reference object at different respective focal lengths, and to determine the optimum focal length at which the reference object is best in focus, and for controlling the adjusting means thereafter to adjust the focal length of the camera to said optimum focal length.

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4 Machine vision equipment as claimed in claim 1, claim 2, or claim 3, characterised in that said second supporting means are configured to support a reference object having substantially the same shape and size in substantially the same orientation in said field of view as the test object.

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5 Machine vision equipment as claimed in any preceding claim, characterised in that said camera comprises a digital camera which is adapted from said image as a regular array of pixels.

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6 Machine vision equipment as claimed in claim 5, characterised in that said configuration determining means comprise calibration determining means adapted to compare an actual measured value of said at least one dimension of said reference object with said accurately known value, said adjusting means are adapted for adjusting the calibration of said imaging means, and said controlling means are configured for controlling said imaging means, calibration determining means and adjusting means for measuring said at least one dimension of said reference object to obtain a measured value, comparing said measured value with the accurately known value, and adjusting the calibration of the imaging means accordingly such that the measured value equals the known value.

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7 Machine vision equipment as claimed in claim 6, characterised in that said second supporting means are adapted to support a plurality of reference objects, each having substantially the same shape as the test object, but each having a different respective, accurately known value of said at least one dimension, said moving means are adapted for selectively moving one or more of the camera, first supporting means and second supporting means to bring each reference object in turn into the camera's field of view at the said predetermined distance from the camera; and said calibration determining means are adapted for comparing the measured value of said at least one dimension of each

reference object with the respective accurately known value, and to generate a calibration curve for said imaging means on the basis of said comparisons.

8 Machine vision equipment as claimed in claim 7, wherein said second supporting means is adapted to support three or more reference objects.

5 9 Machine vision equipment as claimed in claim 8, wherein each reference object comprises a cylindrical bar of accurately known diameter.

10 10 Machine vision equipment as claimed in claim 9, characterised in that said second supporting means comprises at least one holder for holding each reference object, each holder defining a V-shaped cavity which is configured to receive transversely a cylindrical 10 reference bar at the same depth into the cavity regardless of the diameter of the bar.

11 11 Machine vision equipment as claimed in claim 10, wherein said second supporting means comprises two holders for holding each reference object, one holder at or towards each end of the respective bar.

12 12 A method of setting-up machine vision equipment, which equipment comprises 15 imaging means comprising a camera defining a field of view and being adapted to form an image of a test object within said field of view, and processing means for processing said image for determining one or more physical properties of said test object, and first supporting means for supporting a test object at a predetermined distance from said camera within said field of view; said method being characterised by:

20 providing second supporting means for supporting at least one reference object; placing a reference object having at least one accurately known dimension on said second supporting means;

25 selectively moving one or more of said camera, said first supporting means and said second supporting means, such that said reference object is brought into the camera's field of view at said predetermined distance from said camera;

imaging said reference object to obtain at least one image, and processing said at least one image to determine the optimum configuration of the imaging means;

and thereafter adjusting the configuration of said imaging means to said optimum configuration.

30 13 A method as claimed in claim 12, characterised by obtaining and processing a series of images of said reference object whilst adjusting progressively the configuration of the imaging means, and determining the optimum configuration on the basis of said series of images.

14 A method as claimed in claim 13, characterised by adjusting the focal length of the camera while obtaining and processing serial images of the reference object to determine the optimum focal length at which the reference object is best in focus; and thereafter adjusting the focal length of the camera to said optimum focal length.

5 15 A method as claimed in claim 14, characterised by placing on said second supporting means a reference object having substantially the same shape and size in substantially the same orientation in said field of view as the test object.

16 A method as claimed in any of claims 12 to 15, characterised in that said camera comprises a digital camera which is adapted from said image as a regular array of pixels.

10 17 A method as claimed in any of claims 12 to 16, characterised by obtaining an image of said reference object and measuring said at least one dimension, comparing the measured value of said dimension with the accurately known value, and thereafter adjusting the calibration of the imaging means such that the measured value substantially equals the known value.

15 18 A method as claimed in claim 17, characterised by supporting a plurality of reference objects on said second supporting means, each reference object having substantially the same shape as the test object, but each having a different respective, accurately known value of said at least one dimension, selectively moving one or more of the camera, first supporting means and second supporting means to bring each reference object in turn into the camera's field of view at the said predetermined distance from the camera, comparing the measured value of said at least one dimension of each reference object with the respective accurately known value, and generating a calibration curve for said imaging means on the basis of said comparisons.

20 19 A method as claimed in claim 18, characterised by supporting three reference objects on the second supporting means, and imaging those reference objects to produce a calibration curve based on three points.

25 20 A method as claimed in claim 19, wherein each reference object comprises a cylindrical bar of accurately known diameter.

21 21 A method as claimed in claim 20 characterised by supporting each reference object on least one respective holder, said holder defining a V-shaped cavity which is configured to receive a transverse cylindrical reference bar at the same depth into the cavity regardless of the diameter of the bar.

22 A method as claimed in 21, wherein said second supporting means comprises two holders for holding each reference object, one holder at or towards each end of the respective bar.

5 23 A dimensionally stable reference object having at least one accurately known dimension which is fabricated from a ceramic material having a low reflectance or albedo value.

24 A reference object as claimed in claim 23, wherein the reference object comprises a cylindrical bar having an accurately known diameter.

10 25 A reference object as claimed in claim 24 or claim 25, wherein the ceramic material is substantially impervious and has good refractory properties.

26 A reference object as claimed in claim 23, claim 24, or claim 25, characterised in that said ceramic material comprises a ceramic alumina.

15 27 A reference object as claimed in claim 26, wherein said ceramic material has an alumina content of more than about 70% by weight, and more preferably more than about 90% or 95% by weight.

28 A reference object as claimed in claim 26 or claim 27, wherein the ceramic material comprises various other ceramic constituents, particularly magnesium oxide.

20 29 A reference object as claimed in any of claims 23 to 28, wherein the ceramic material comprise about 99.7% weight alumina, with the balance being substantially magnesium oxide.